4.17 SITE CONTAMINATION AND REMEDIATION

This section describes the history, current status, and ongoing and planned remediation activities of contaminated soil and groundwater at LLNL. Separate discussions are presented for the Livermore Site and Site 300.

4.17.1 Site Contamination—Livermore Site

4.17.1.1 *Contamination History*

LLNL was founded at the Livermore Site in 1952 at a former U.S. Navy training base. Initial releases of hazardous materials occurred at the Livermore Site in the mid-to-late 1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, leaking tanks and impoundments, and landfills contributed VOCs, fuel hydrocarbons, lead, chromium, and tritium to the groundwater and unsaturated sediment in the post-Navy era. The major contaminants are VOCs, primarily TCE. Environmental investigations and clean-up activities at the Livermore Site began in 1981. The Livermore Site was placed on the NPL in 1987 for cleanup under CERCLA. By the end of FY2006, DOE, depending on budget allocations, will have in place remediation facilities for long-term stewardship (in some cases, 50 to 60 years). The CERCLA environmental restoration treatment facilities and areas (see descriptions below) are shown in Figure 4.17.1.1–1. Contaminant release sites are assigned to 12 treatment facility (TF) areas, based on the nature and extent of contamination, infrastructure, and topographic and hydrologic considerations. The 12 areas are TFA, TFB, TFC, TFD, TFE, TFF406, TFG, TF518, TF5475, Building 331 area, Building 419/511 area, and Building 292 area. TF areas include both groundwater and vapor treatment facilities (VTFs). For 2002, the groundwater extraction wells operated at an average flow rate of 1,787 liters per minute; the vapor extraction average flow rate was 0.27 cubic meter per minute.

The objective of the TFs is to prevent the further movement of groundwater offsite, to remediate groundwater to drinking water standards, and to remediate the sources of contamination. Cleanup at each TF area includes groundwater monitoring, data analysis, and modeling. The results of the data analyses are used in decisionmaking for continued remediation optimization.

4.17.1.2 *Contamination Treatment Facilities and Areas*

Treatment Facility Area A

Treatment Facility Area A (TFA) is located in the southwest corner of the Livermore Site. Beginning operation in 1989, it is the oldest operating groundwater treatment system (GWTS) at the Livermore Site.

The TFA groundwater plumes affect approximately 98 acres, of which about 56 acres are located offsite. In 2002, TFA treated 251.4 million liters of groundwater, removing 5.7 kilograms of VOCs (Table 4.17.1.2–1). While the size of the offsite VOC plumes remained largely the same, the concentrations have declined below MCLs in most locations. The contaminants of concern are presented in Table 4.17.1.2–2.

TABLE 4.17.1.2–1.—*Volatile Organic Compounds Removed from Groundwater and Soil at the Livermore Site*

		2002		Cumulative Total	
Treatment Area	**Startup Date**	**Water Treated (million liters)**	**VOCs Removed (kilograms)**	**Water Treated (million liters)**	**VOCs Removed (kilograms)**
TFA	1989	251.4	5.7	3,658	154
TFB	1990	130.2	6.1	787	54.2
TFC	1993	107.9	7.1	595	53.9
TFD	1994	281.3	68.4	1,505	500
TFE	1996	110.5	17.5	544	139
TFG	1996	12.1	0.7	70.4	3.7
TF406	1996	40.5	1.0	211	7.7
TF518	1998	4.9	0.6	37.1	4.3
TF5475	1998	0.72	0.7	2.3	4.8
Total [a]		**939**	**108**	**7,410**	**922**
		Soil Vapor Treated (thousand cubic meters)	**VOCs Removed (kilograms)**	**Soil Vapor Treated (thousand cubic meters)**	**VOCs Removed (kilograms)**
VTF518	1995	0	0	425	153
VTF5475	1999	143.5	37.7	659	306
Total [a]		**144**	**38**	**1,084**	**459**

Source: LLNL 2003l.
[a] Rounded to nearest whole number.
TF = treatment facility; VOC = volatile organic compound; VTF = vapor treatment facility.

TFA was constructed to prevent VOCs from migrating downgradient toward municipal water supply wells to the west and agricultural and domestic wells to the south. Groundwater is treated using the large capacity air-stripping system installed in June 1997, replacing an ultraviolet hydrogen peroxide system. VOCs are stripped from the groundwater, and the effluent air from the stripper is passed through granular activated carbon filters to remove VOCs. The treated effluent air is then vented to the atmosphere. Another TF in the TFA uses granular activated carbon to remove VOCs and is solar powered.

In the TFA area, depth to groundwater is about 75 feet and groundwater flows to the west. Contaminants are generally confined from 75 to 140 feet below ground surface.

Treatment Facility Area B

Treatment Facility Area B (TFB) is located along Vasco Road on the western edge of the Livermore Site. TFB, which began operating in 1990, is the second oldest operating GWTS at the Livermore Site.

The TFB groundwater plumes affect approximately 27 acres, of which all are located onsite. In 2002, TFB treated 130.2 million liters of groundwater from six wells, removing 6.1 kilograms of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TFB was constructed to prevent VOCs from migrating downgradient toward a residential area to the west. Groundwater is treated using a large capacity air-stripping system installed in October 1998. This unit replaced an ultraviolet/hydrogen peroxide system that had been in use since 1990. Groundwater is also treated for hexavalent chromium using an ion-exchange unit. Treated

groundwater from TFB is discharged into the north-flowing drainage ditch parallel to Vasco Road, which empties into Arroyo Las Positas to the north.

TABLE 4.17.1.2–2.—*Contaminants of Concern, Including Sources, by Treatment Area*

Treatment Area	Brief Source[a] Description	Contaminants of Concern
TFA	Local storm drain outlets, spills into the retention tanks, and a transformer rupture	Primarily tetrachloroethylene and to a lesser degree TCE and 1,1-dichloroethylene
TFB	Local dumping of oils and solvents, open sewer lines, plating shop sumps, etc.	Primarily tetrachloroethylene and to a lesser degree TCE, 1,1-dichloroethylene, carbon tetrachloride, and other solvents. Hexavalent chromium is also present.
TFC	Releases from buildings, cooling tower discharges, tank leaks, etc.	Primarily tetrachloroethylene and TCE and to a lesser degree 1,1-dichloroethylene and chloroform. Hexavalent chromium is also present.
TFD	A number of sources including the old runways of the former Livermore Naval Air Station and landfills	TCE, trichlorofluoromethane, and other solvents. Hexavalent chromium is also present.
TFE	Underground storage tanks, oil, and chemical spills, etc.	TCE, tetrachloroethylene, and 1,1-dichloroethylene
TFF 406	Fuel and spills	Fuel hydrocarbons, toluene, benzene, etc. Chlorinated solvents are also present.
TFG	Floor drains, drum racks, potential releases from shops, spills, and leaking equipment	TCE and tetrachloroethylene
TF518	Accidental spills, solvent storage	Primarily tetrachloroethylene, TCE, and 1,1-dichloroethylene
TF5475	Former waste disposal pits and evaporation ponds	Tritium and chlorinated solvents.
Building 331	Tritium Facility operations	Tritium and solvents
Building 419/511	Former Navy aircraft assembly and maintenance operations	Primarily tetrachloroethylene, TCE, and carbon tetrachloride
Building 292	Former energy research facility	Tritium and VOCs

Source: LLNL 2003l.
[a] Source of contamination is based on best available information and may not be completely known.
TF = treatment facility; VOC = volatile organic compound.

Depth to groundwater is about 60 feet and groundwater flows to the west. Contaminants are generally confined from 60 to 120 feet below ground surface.

Treatment Facility Area C

Treatment Facility Area C (TFC) is located in the northwest part of the Livermore Site. TFC, which began operating in 1993, is the third oldest operating GWTS at the Livermore Site.

The TFC groundwater plume affects approximately 110 acres, all of which are located onsite. In 2002, TFC treated 107.9 million liters of groundwater, removing 7.1 kilograms of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TFC was constructed to prevent VOCs from migrating downgradient toward a residential area to the west. TFC treats VOCs in groundwater using air stripping. The effluent air from the stripper is treated with granular activated carbon prior to discharge to the atmosphere. Groundwater is treated for hexavalent chromium using an ion-exchange unit. Treated groundwater from TFC is discharged into Arroyo Las Positas to the north.

The depth to groundwater is about 45 feet and groundwater flows to the west. Contaminants are generally confined from 45 to 65 feet below ground surface.

Treatment Facility Area D

Treatment Facility Area D (TFD) is located in the northeast quadrant of the Livermore Site. TFD, which began operating in 1994, is the fourth oldest operating GWTS at the Livermore Site.

The TFD groundwater plumes affect approximately 111 acres, all located onsite. In 2002, TFD treated 281.3 million liters of groundwater, removing 68.4 kilograms of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TFD was constructed to prevent VOCs from migrating downgradient onsite and to clean up source areas near TFD. Fixed and portable TFs, operating in the TFD area, process VOCs in groundwater using air stripping. The effluent air from the air strippers is treated with granular activated carbon prior to discharge to the atmosphere. Treated groundwater from TFD is discharged either into the Drainage Retention Basin (DRB), into an underground pipeline downstream of the DRB weir, into a nearby storm sewer, or into drainage ditches, each flowing north into the DRB. All discharge eventually empties into Arroyo Las Positas.

Depth to groundwater is about 70 feet and groundwater flows to the west. Contaminants are generally confined from 70 to 140 feet below ground surface.

Treatment Facility Area E

Treatment Facility Area E (TFE) is located in the central eastern part of the Livermore Site. TFE, which began operating in 1996, is one of three operating GWTSs that were activated in 1996 at the Livermore Site.

The TFE groundwater plumes affect approximately 42 acres, located onsite. In 2002, TFE treated 110.5 million liters of groundwater, removing 17.5 kilograms of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TFE was constructed to prevent VOCs from migrating downgradient onsite and to clean up nearby contaminant source areas. VOCs are treated using an air stripper. Before the effluent air is vented to the atmosphere, it is treated using granular activated carbon to remove VOCs. Treated groundwater is discharged into a drainage ditch that flows north into the DRB.

Depth to groundwater is about 75 feet and groundwater flows to the west. Contaminants are generally confined from 75 to 120 feet below ground surface.

Treatment Facility Area F 406

Treatment Facility Area F 406 (TFF406) is located in the central southern area of the Livermore Site. TFF began operation in 1991 as a pilot study, testing vacuum-induced venting followed by stripping to remediate hydrocarbons at the site of an old gasoline station. By 1996, the vadose (unsaturated) zone remediation was complete and only residual concentrations of hydrocarbons remained in the saturated zone. No further action status for hydrocarbons was granted in 1996. TFF406 began operating in 1996 to treat VOCs as one of three GWTSs activated in 1996 at the Livermore Site. Treated groundwater is discharged into storm drains leading to Arroyo Las Positas.

There is no unsaturated zone soil contamination in the TFF406 area requiring remediation. The TFF406 groundwater VOC plume is approximately 9 acres and is located onsite and south of East Avenue (extending offsite by approximately 750 feet), including a portion of the SNL/CA site. In 2001, TFF 406 treated 40.5 million liters of groundwater, removing 1.0 kilogram of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TFF406 was constructed to prevent VOCs from migrating downgradient toward municipal water supply wells to the west and agricultural wells and domestic wells to the south. TFF406 uses an air stripper to treat VOCs in groundwater. Granular activated carbon removes VOCs from effluent air prior to discharge to the atmosphere. All treated groundwater is discharged to an underground storm drain that flows north to Arroyo Las Positas.

Depth to groundwater is about 100 feet and groundwater flows to the west. Contaminants are generally confined from 150 to 190 feet below ground surface.

Treatment Facility Area G

Treatment Facility Area G (TFG) is located in the central south region of the Livermore Site. TFG, which began operating in 1996, is one of three operating GWTSs activated in 1996 at the Livermore Site.

The TFG groundwater plumes affect approximately 77 acres, all located onsite. In 2002, TFG treated 12.1 million liters of groundwater, removing 0.7 kilogram of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TFG was constructed to prevent VOCs from migrating downgradient onsite. Depth to groundwater is about 70 feet and groundwater flows to the west. Contaminants are generally confined from 70 to 90 feet below ground surface.

Treatment Facility Area 518

Treatment Facility Area 518 (TF518) is located in the southeast corner of the Livermore Site. TF518, which began operating in 1998, is one of several recent additions to operating GWTSs at the Livermore Site.

The TF518 groundwater plume affects approximately 15 acres, most located onsite. The remainder extends south of East Avenue by several hundred feet, including a portion of the

SNL/CA site. In 2002, TF518 treated 4.9 million liters of groundwater, removing 0.6 kilogram of VOCs (Table 4.17.1.2–1). The contaminants of concern are presented in Table 4.17.1.2–2.

TF518 was constructed to prevent VOCs from migrating downgradient toward SNL/CA to the south. Depth to groundwater is about 110 feet and groundwater flows to the west. Contaminants are generally confined from 110 to 130 feet below ground surface.

Treatment Facility Area 5475

Treatment Facility Area 5475 (TF5475) is located in the southeastern region of the Livermore Site. TF5475, which began operating in 1998, is one of several recent additions to operating GWTSs at the Livermore Site.

The TF5475 groundwater plumes affect approximately 11 acres, all located onsite. In 2002, TF5475 treated 0.38 million liters of groundwater, removing 0.7 kilograms of VOCs (Table 4.17.1.2–1). Also, tritium concentrations remained below the MCL and continued to decrease. The contaminants of concern are presented in Table 4.17.1.2–2.

TF5475 was constructed to prevent VOCs and tritium from migrating downgradient toward SNL/CA to the south and remediate contaminant sources in the area. Depth to groundwater is about 85 feet and groundwater flows to the west. Contaminants are generally confined from 85 to 130 feet below ground surface.

Building 331 Area

Environmental restoration activities in the Building 331 area, located in the south-central region of the Livermore Site, include groundwater monitoring and sampling. Building 331, which began operating in 1959, once provided primary support to the LLNL weapons program. The main effluent releases from this building were gaseous tritium discharges through 100-foot-high stacks. NNSA expects no active soil vapor treatment system will be required as the tritium naturally decays.

The Building 331 area groundwater plume affects approximately 2 acres; the entire plume is located in the vicinity of Building 331, also referred to as the Tritium Facility. The primary contaminant of concern is tritium as presented in Table 4.17.1.2–2.

The Building 331 area is monitored for tritium migration. Depth to groundwater is about 70 feet. Tritium is generally confined to this depth and the vadose (unsaturated) zone.

Building 419/511 Area

Environmental restoration activities in the Building 419/511 area, located in the southeastern quadrant of the Livermore Site, include groundwater monitoring and sampling. The area was part of the former Naval Site, where aircraft assembly and maintenance was completed. Building 419 was used as an assay lab and then as a decontamination and size reduction facility by the RHWM Division, for which a partial RCRA closure was completed. NNSA expects to continue to monitor the area until cleanup standards are reached or the building is demolished or decommissioned.

The Building 419/511 area groundwater plume affects approximately 3 acres, located near Building 419/511. The contaminants of concern are presented in Table 4.17.1.2–2. VOCs removed at Building 419/511 are included in the TF518 results on Table 4.17.1.2–1.

Building 292 Area

Environmental restoration activities in the Building 292 area, located in the northwestern part of the Livermore Site, include tritium monitoring and sampling around the building. Building 292 housed a rotating target neutron source that was used for energy research. DOE expects to continue to monitor the area until cleanup standards are reached.

The Building 292 area groundwater plume affects approximately 3 acres, all located in the vicinity of Building 292. Tritium is the primary contaminant of concern (Table 4.17.1.2–2).

Spills

Small, localized chemical, oil, or hazardous material spills or releases have occurred at the site in the past. The possibility of a spill occurring still exists, given the variety of materials handled at LLNL. Some buildings use a variety of chemicals, including solvents, paints, and industrial gases (Section 4.15.1); however, industry-accepted controls are in place to minimize the potential for soil contamination from any ongoing LLNL operations.

The RHWM Division stores, treats, and handles hazardous and radioactive wastes prior to shipment offsite for disposal. These facilities have the potential for hazardous spills, releases, or fires. The RHWM Division is responsible for maintaining control and countermeasures to prevent and protect the environment in accordance with the site's hazardous waste permit. At the waste management facilities, industry-accepted controls are in place to minimize the potential for soil contamination from any LLNL waste management facility operations.

4.17.1.3 *Remedial Actions*

Status of Remediation Efforts

Since remediation began in 1989, the concentrations within the Livermore Site VOC plumes has been decreasing (Figure 4.17.1.3–1). Most of the observed trends in VOC concentrations are attributed to active groundwater extraction and remediation. Notable results of VOC analyses of groundwater are discussed below.

VOC concentrations on the western margin of the site either declined or remained unchanged during 2002, indicating continued hydraulic control of the western site boundary plumes in the TFA, TFB, and TFC. Concentrations in the TFA and TFB source areas increased slightly, however. The entire offsite Hydrostratigraphic Unit 2 plume from TFA dropped below 50 parts per billion for the first time (hydrostratigraphic units are shown in Figure 4.17.1.1–1).

In TFB, VOC concentrations were lower in Hydrostratigraphic Unit 1B close to Vasco Road, where TCE declined from 23 parts per billion in 2001 to 14 parts per billion in 2002.

In the central to northern parts of TFC, the lateral extent of Hydrostratigraphic Unit 1B total VOC concentrations above 50 parts per billion decreased significantly. Total VOC concentrations decreased along the western margin of TFC.

Concentrations began to decline in 2002 in a Hydrostratigraphic Unit 2 plume located in the western part of TFE in response to pumping. TCE declined from 220 parts per billion in 2001 to 76 parts per billion in one extraction well in 2002.

Hydrostratigraphic Unit 3A total VOC concentrations continued to decline in the T5475 area in 2002 due to a combination of soil vapor extraction and regional dewatering of Hydrostratigraphic Unit 3A. VOCs in Hydrostratigraphic Units 3A, 3B, and 4 declined in the south-central part of TFD in response to pumping. Hydrostratigraphic Unit 4 TCE concentrations also declined in the southwestern part of TFE due to ongoing pumping.

Significant decreases in Hydrostratigraphic Unit 5 VOC concentrations were observed in TFF406 during 2002 in response to groundwater extraction, particularly at SNL/CA south of East Avenue. TCE in one well at the leading edge of a TCE plume, declined from 27 parts per billion in 2001 to less than 0.5 part per billion in 2002. Closer to TFF406, TCE in one well declined from 31 parts per billion to 9 parts per billion over the same period.

Proposed Remedial Actions

LLNL and NNSA believe that the following proposed major milestones would continue to best meet the criteria established in the original 1992 CERCLA Record of Decision (ROD) for this site (DOE 1992a) and the most recent five-year review:

FY2004

- Begin Helipad source area remediation
- Begin TF518 perched-zone remediation
- Begin Southern East Traffic Circle source area remediation

FY2005

- Begin TFD hotspot remediation
- Begin TFE hotspot remediation
- Begin Northern East Traffic Circle source area remediation
- Begin TF406 hotspot remediation

FY2006

- Begin Building 419 source area remediation
- Begin TF406 South remediation

- Begin TFB/C source area remediation
- Begin Buildings 511/514 source area remediation
- Begin TF5475 South remediation

By the end of FY2006, NNSA expects that approximately 38 groundwater remediation systems will be in place. NNSA's ongoing investigations are focused on identifying all remaining sources of groundwater contamination. The goals of groundwater remediation are to remove contaminant mass, reduce contaminant concentrations, and contain the migration of the plumes. NNSA will continue to operate pump treat systems until cleanup levels are achieved. NNSA plans to manage remedial sites as part of the site-wide long-term stewardship effort.

4.17.2 Site Contamination—Site 300

4.17.2.1 *Contamination History*

LLNL Site 300 is a NNSA experimental test facility that conducts research, development, and testing associated with high explosives materials. During past Site 300 operations, contaminants were released to the environment from surface spills and pipe leaks, leaching from unlined landfills and pits, high explosive test detonations, and disposal of waste fluids in lagoons and dry wells. LLNL began environmental investigation and restoration activities in 1981, and the site was placed on the NPL in 1990. The primary contaminants of concern at Site 300 include VOCs, high explosive compounds, perchlorate, tritium, depleted uranium, nitrate, PCBs, dioxins, furans, silicone oils, and metals (Table 4.17.2.1–1).

All contaminant release sites at Site 300 are assigned to one of eight operable units (OUs) (see Figure 4.11.3.4–2), based on the nature and extent of contamination and hydrogeologic considerations. More detailed background information for Site 300 environmental characterization activities may be found in the *Final Site-wide Remedial Investigation Report*, *Lawrence Livermore National Laboratory Site 300* (LLNL 1994a, LLNL 1994b), and the *Final Site-wide Feasibility Study*, *Lawrence Livermore National Laboratory Site 300* (LLNL 1999d).

In 2001, NNSA and the regulatory agencies signed an interim site-wide ROD in which interim remedial actions were selected for the cleanup of Site 300. This ROD was designated as interim to ensure remediation activities commence while additional testing and evaluation of cleanup technologies occur and final groundwater cleanup standards are negotiated. The overall NNSA/LLNL remedial strategy for Site 300 is to achieve a rapid, efficient, and cost-effective cleanup within budgetary constraints and in compliance with regulatory requirements. The selected interim remedies are being implemented in phases using a prioritized, risk-based approach.

More detailed information for the interim remedial actions at Site 300 may be found in the *Interim Site-wide Record of Decision*, *Lawrence Livermore National Laboratory Site 300* (LLNL 2001u), and the *Remedial Design Work Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300* (LLNL 2001i).

TABLE 4.17.2.1–1.—*Major Groundwater Contaminants of Concern at Site 300*

Operable Unit (OU)	Contaminant(s) of Concern
General Services Area (GSA) (OU1)	VOCs (primarily TCE)
Building 834 Complex (OU2)	VOCs (primarily TCE), organosilicate oil, nitrate
High Explosives Process Area (OU4)	VOCs (primarily TCE), high explosive (primarily RDX), nitrate, perchlorate
Building 850/Pits 3 and 5 (OU5)	Tritium, depleted uranium, VOCs (primarily TCE), nitrate, perchlorate
Building 854 (OU6)	VOCs (primarily TCE), nitrate, perchlorate
Pit 6 (OU3)	VOCs (primarily TCE), tritium, nitrate, perchlorate
Building 832 Canyon (OU7)	VOCs (primarily TCE), nitrate, perchlorate
Site 300 (OU8)	VOCs (primarily TCE and Freon 113), nitrate, perchlorate, depleted uranium, tritium metals, RDX

Source: LLNL 2003l.
RDX = cyclo-1, 3, 5 – trimethylene – 2, 4, 6 - trinitramine; TCE = trichloroethene; VOC = volatile organic compound

4.17.2.2 *Operable Units*

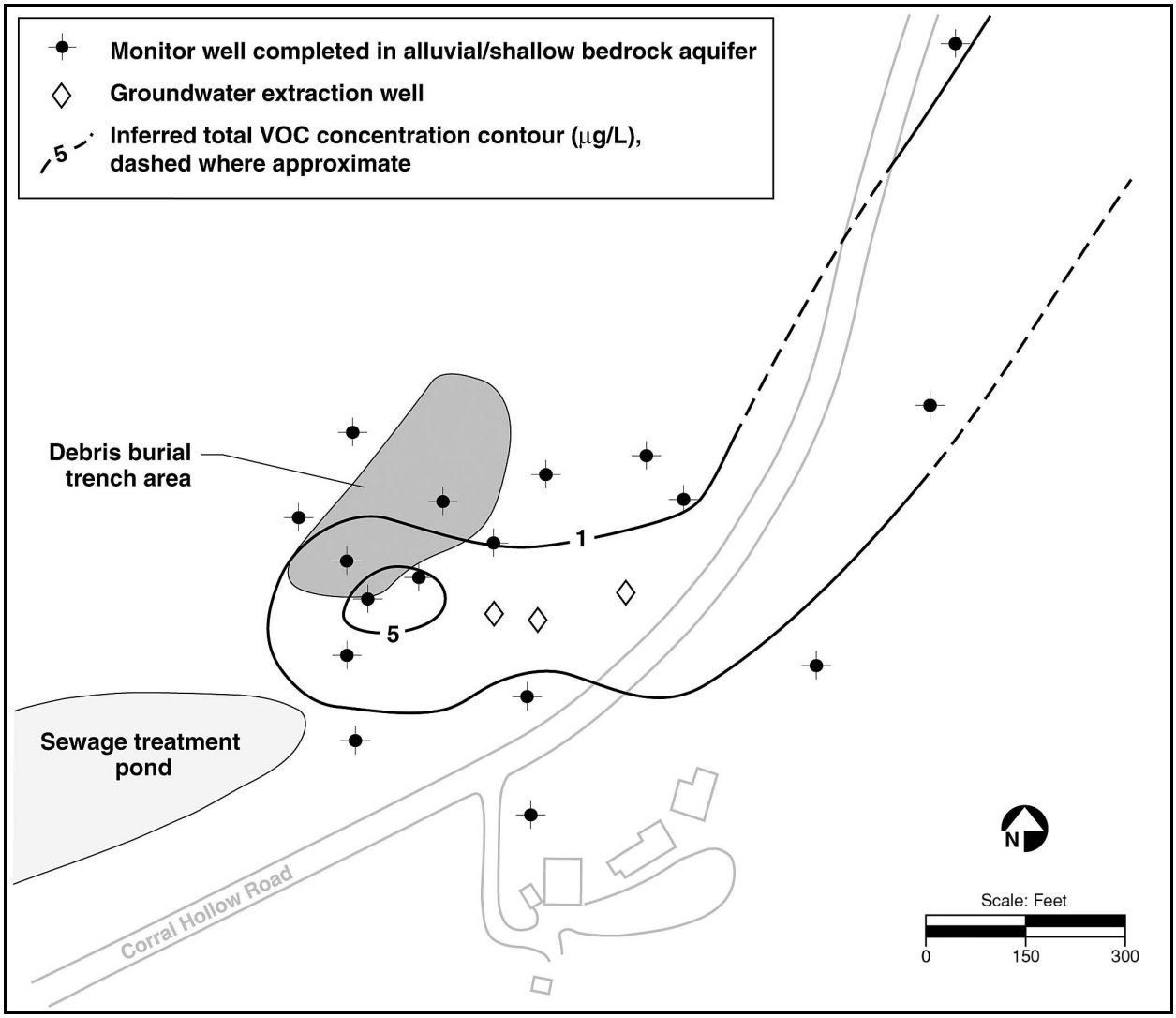
The following sections briefly summarize background information and characterization activities for each of the operable units.

General Services Area Operable Unit

TCE and other solvent-related VOCs were released to the soil and groundwater as a result of past activities in the craft shops and equipment fabrication and repair facilities in the GSA. For the purposes of remediation management, the GSA has been subdivided into the eastern and central GSA subareas, based on differences in contaminant sources and hydrogeology. The eastern and central GSA subareas are discussed individually below.

Eastern General Services Area

In the eastern GSA, the highest VOC concentrations in groundwater occur in the vicinity of a former debris burial trench area where craft shop debris was disposed of in the 1960s and 1970s. A VOC groundwater plume, shown in Figure 4.17.2.2–1, extends approximately 1,400 feet east and northeast of the burial trench area in the direction of alluvial groundwater flow. The depth to groundwater in this area is 10 to 30 feet below ground surface. The maximum total VOC concentration detected in groundwater collected from eastern GSA wells in the fourth quarter of 2002 was 7.5 micrograms per liter (LLNL 2003l).



Source: LLNL 2003l.

FIGURE 4.17.2.2–1.—*Total Volatile Organic Compound Concentrations in Groundwater in the Eastern General Services Area and Vicinity (Fourth Quarter, 2002)*

In 1991, an extraction and treatment system was installed and began to remove VOCs from groundwater. In 1997, an area-specific ROD was signed in which a remedial action for the cleanup of the eastern GSA was selected. The selected remedy includes continued groundwater vapor extraction and treatment. The volume of groundwater treated and mass of VOCs removed by the eastern GSA facility through 2002 are presented in Table 4.17.2.2–1. The eastern GSA treatment facility effluent discharge is regulated under an NPDES permit issued by the Central Valley RWQCB.

Before treatment commenced in 1991, a TCE groundwater plume extended more than a mile offsite. By 2001, the TCE plume, as defined by the 5-micrograms-per-liter TCE isoconcentration contour, was contained onsite with only two onsite wells containing TCE at concentrations slightly above the safe drinking water standard of 5 micrograms per liter. The effectiveness of

the remediation effort in the eastern GSA is reevaluated every 5 years in the GSA Five-Year Review report (LLNL 2001ba).

TABLE 4.17.2.2–1.—*Volatile Organic Compounds Removed from Groundwater and Soil Vapor at Site 300 through 2002*

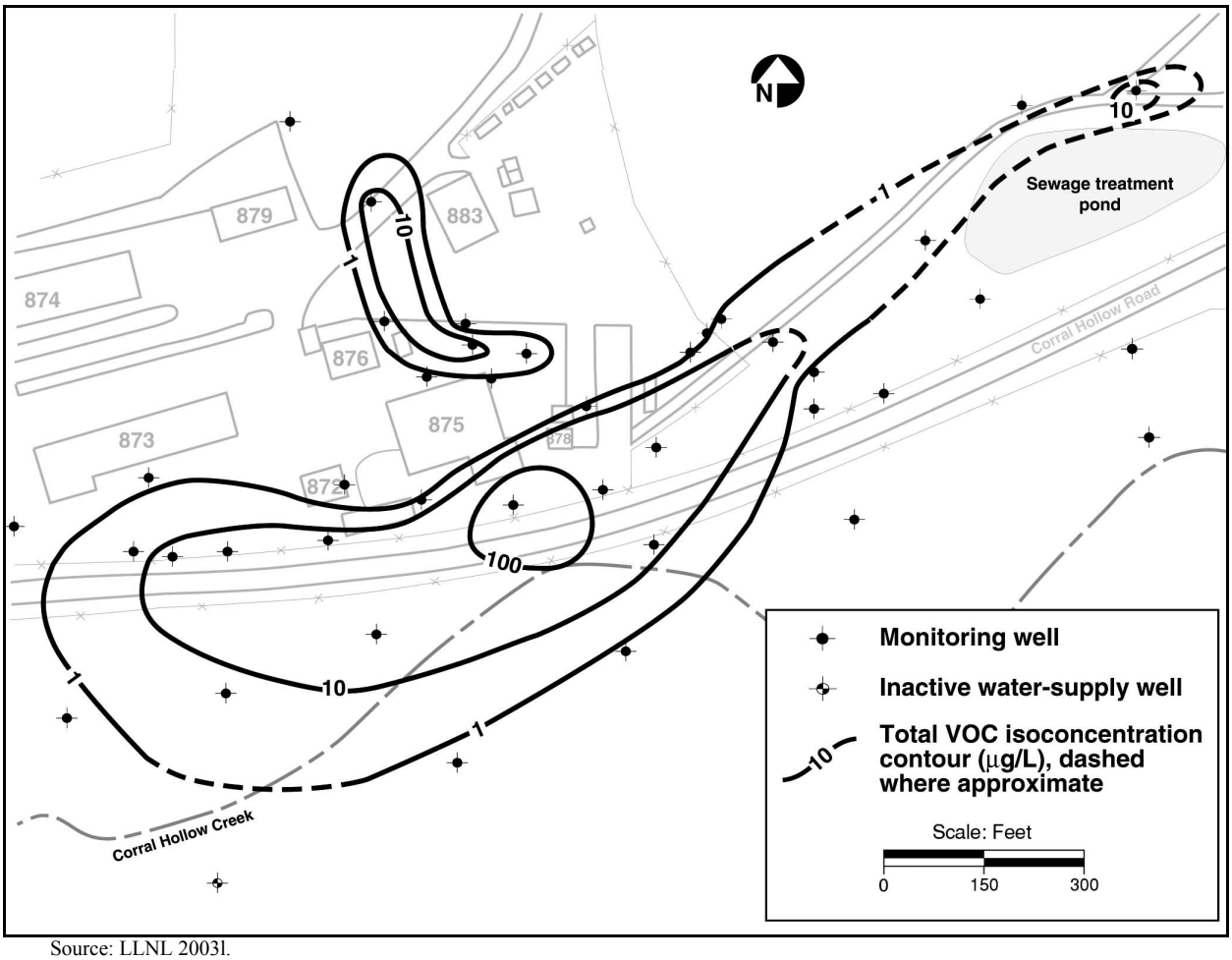
Treatment Area		2002		Cumulative Total	
	Startup Date	Water Treated (million liters)	VOCs Removed (kilograms)	Water Treated (million liters)	VOCs Removed (kilograms)
Eastern GSA	1991	78.7	0.17	806.6	6.19
Central GSA	1993	4.19	0.59	29.16	10.66
Building 834	1995	0.11	0.81	0.93	31.84
High Explosives Process Area	1999	4.5	0.012	10.5	0.058
Building 832	1999	1.90	0.12	5.68	0.44
Building 854	1999	3.67	0.78	12.25	6.14
Pit 6	1998	Not Applicable	Not Applicable	0.268	0.0014
Total		**93.1**	**2.48**	**865.4**	**55.33**
		Soil Vapor Treated (thousand cubic meters)	**VOCs Removed (kilograms)**	**Soil Vapor Treated (thousand cubic meters)**	**VOCs Removed (kilograms)**
Central GSA	1994	293.58	1.54	1,987.18	66.16
Building 834	1998	406.18	5.19	1,657.56	108.26
Building 832	1999	96.2	0.28	282.5	1.39
Total		**795.96**	**7.01**	**3,927.44**	**175.81**

Source: LLNL 2003l.
GSA = General Services Area; VOC = volatile organic compound.

Central General Services Area

In the central GSA, VOCs were released to the ground in wastewater from the craft and repair shops and as leaks/spills from solvent storage tanks or drums. TCE typically comprises 85 to 95 percent of the total VOCs detected in the subsurface. These releases originally affected approximately 33,900 cubic yards of soil onsite. Two VOC plumes in the central GSA, shown in Figure 4.17.2.2–2, are present in groundwater at a depth of 10 to 30 feet below ground surface. The northern plume is approximately 350 feet long and is contained onsite. The plume located south of Building 875 is approximately 1,600 feet long and extends about 250 feet offsite. TCE concentrations in groundwater in the central GSA area have decreased over time from an historical maximum of 240,000 micrograms per liter to 958 micrograms per liter in 2002. VOC concentrations in soil/bedrock have also been significantly reduced.

In 1995, an extraction and treatment system was installed in the central GSA to remediate VOCs in both soil/bedrock and groundwater. In 1997, an area-specific ROD was signed in which the remedial action for the cleanup of the central GSA was selected. The selected remedy includes continued groundwater and soil vapor extraction (SVE) and treatment. The volume of groundwater and soil vapor treated and mass of VOCs removed by the central GSA facility through 2002 are presented in Table 4.17.2.2–1. The central GSA treatment facility effluent discharge is regulated under Substantive Requirements for Wastewater Discharge issued by the Central Valley RWQCB. The effectiveness of the remediation effort in the central GSA is reevaluated every five years in the GSA Five-Year Review report (LLNL 2001ba).



Source: LLNL 2003l.

FIGURE 4.17.2.2–2.—*Total Volatile Organic Compound Concentrations in Groundwater in the Central General Services Area (Fourth Quarter, 2002)*

Building 834, Operable Unit 2

Facilities at the Building 834 Complex have been used since the late 1950s to conduct thermal-cycling experiments on weapon components. Aboveground pipes carried TCE-based heat-exchange fluid from the main buildings to and from surrounding test cells. Occasionally, TCE was mixed with silicone oil to prevent the degradation of pump seals and gaskets.

From 1962 to 1978, intermittent spills and piping leaks resulted in the contamination of the subsurface bedrock and shallow groundwater with TCE and silicone oils. These releases originally affected approximately 33,900 cubic yards of soil. The TCE groundwater contamination extends approximately 1,100 feet downgradient from the source area in several discrete, shallow, perched, water-bearing zones as shown in Figure 4.17.2.2–3. TCE concentrations in groundwater in the Building 834 area have decreased over time from an historical maximum of 800,000 micrograms per liter to 87,000 micrograms per liter in 2002. Nitrate contamination in groundwater results from septic system effluent but may also have natural sources.

In 1995, an extraction and treatment system was installed that simultaneously extracts contaminated soil vapor and groundwater from the subsurface. Studies have shown that natural biodegradation of TCE through anaerobic dehalogenation has been occurring in the source area of Building 834. Treatability studies, focusing on understanding and enhancing the bioremediation process, are underway.

An area-specific interim ROD was signed in 1995 that was superceded by the interim site-wide ROD in 2001. The selected interim remedy for Building 834 includes continued groundwater and SVE and treatment using an expanded well field. The volume of groundwater and soil vapor treated and mass of VOCs removed by the Building 834 facility through 2002 are presented in Table 4.17.2.2–1. The Building 834 treatment facility effluent discharge is regulated under Substantive Requirements for Wastewater Discharge issued by the Central Valley RWQCB. A five-year review was completed in 2002 to reevaluate the effectiveness of the remediation effort in the Building 834 operable unit (LLNL 2001ab).

High Explosives Process Area, Operable Unit 4

The High Explosives Process Area was established in the 1950s to chemically formulate, mechanically press, and machine high explosive compounds into detonation devices that are tested in explosive experiments at Site 300. The High Explosives Process Area Operable Unit includes Building 815, high explosive lagoons, high explosive burn pit release sites, and related downgradient groundwater plumes. Depth to groundwater in the High Explosives Process Area ranges from 30 to 250 feet below ground surface.

Surface spills at the former Building 815 steam plant resulted in TCE contaminant plumes that extend up to 3,000 feet from the source area (Figure 4.17.2.2–4). VOC concentrations in the Building 815 area have decreased over time from an historical maximum of 1,000 micrograms per liter to 80 micrograms per liter in 2002. In 1999, a groundwater extraction and treatment system was installed at the site boundary to prevent offsite migration of the TCE plume. In 2000 and 2002, additional extraction and treatment systems were installed at and downgradient from the Building 815 source area to remove TCE mass and prevent further plume migration.

From the late 1950s to 1985, wastewater containing high explosive compounds, nitrate, and perchlorate was discharged to unlined rinse water lagoons. These lagoons are thought to be the primary source of high explosive compounds, nitrate, and perchlorate in groundwater. The plumes of high explosive compounds and perchlorate extend approximately 700 and 2,000 feet, respectively, downgradient from the lagoon source area. High explosive compound concentrations have decreased with time. There is evidence that the nitrate present in groundwater is naturally attenuated through denitrification processes in the aquifer. The former rinse water lagoons were capped and closed in 1989 to prevent further releases of high explosive compounds and associated constituents (nitrate and perchlorate).

From the late 1950s to 1998, three burn pits were used to burn high explosive particulates and cuttings, explosive chemicals, and explosives-contaminated debris. High explosive compounds have been detected at low levels in soil but do not present a risk to human health or threat to groundwater. Groundwater data indicate that TCE, believed to be from a spill at an adjacent waste storage area, has affected groundwater. The high explosive burn pits were capped and closed under RCRA in 1998.

The selected interim remedy for the High Explosives Process Area Operable Unit includes continued and expanded groundwater extraction and treatment. The volume of groundwater and soil vapor treated and the mass of VOCs removed by the High Explosives Process Area treatment facilities through 2002 are presented in Table 4.17.2.2–1. The High Explosives Process Area treatment facility effluent discharges are regulated under Substantive Requirements for Wastewater Discharge issued by the Central Valley RWQCB.

Building 850/Pits 3 and 5, Operable Unit 5

The Building 850/Pits 3 and 5 Operable Unit includes the Building 850 firing table and sand pile, landfill Pits 3 and 5, and groundwater plumes originating at the Building 850 release site and Landfill Pits 2, 3, 5, and 7.

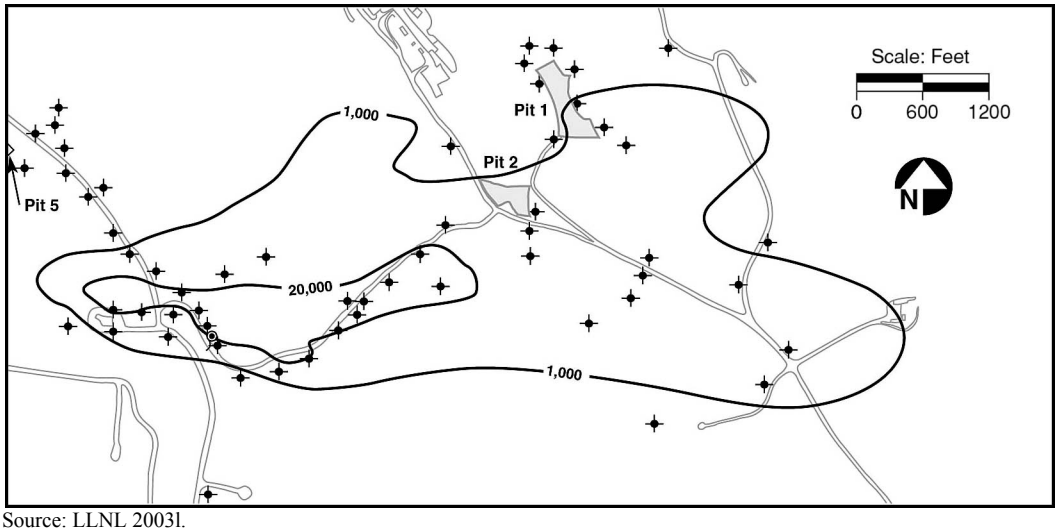
The Building 850 firing table has been used to conduct high explosive experiments since 1958. Tritium was used in some of these experiments, primarily between 1963 and 1978. As a result of the destruction and dispersal of test assembly debris during detonations, surface soil was contaminated with metals, PCBs, dioxins, furans, cyclotetramethylene tetranitramine, and depleted uranium. Leaching from firing table debris has resulted in tritium and depleted uranium in groundwater. Nitrate has also been identified in groundwater.

Gravel was removed from the firing table in 1988 and placed in the Pit 7 landfill. PCB-contaminated shrapnel and debris were removed from the area around the firing table in 1998. The selected remedy for the Building 850 area includes the excavation of the contaminated surface soil and a nearby sand pile as a final remedy and monitored natural attenuation of tritium in groundwater as an interim remedy.

Landfill Pits 3 and 5 were used from 1958 to 1967 to dispose of firing table debris and from 1968 to 1979, to dispose of firing table gravel. VOCs, tritium, depleted uranium, nitrate, and perchlorate were released from these landfills as a result of leaching of these contaminants from the pit waste. Data indicate continued releases of tritium are occurring as groundwater rises into the pits during high rainfall years (i.e., during El Niño). TCE concentrations in groundwater in the vicinity of the Pit 5 release area have decreased to below drinking water standards (5 micrograms per liter).

Depth to groundwater ranges from 15 to 65 feet below ground surface in Operable Unit 5. The tritium emanating from Pits 3 and 5 flows to the south-southeast in shallow alluvial groundwater and commingles with the tritium plume emanating from Building 850 (Figure 4.17.2.2–5). The total length of the commingled tritium plume is about 10,000 feet. Tritium has also been detected in bedrock groundwater that flows northeast of the pits. Concentrations of depleted uranium in groundwater near Pits 3 and 5 remain above drinking water standards while depleted uranium levels in groundwater in the vicinity of Building 850 are well below drinking water standards.

A remedial investigation/feasibility study is in progress for the Pits 3 and 5 areas. Source isolation and containment technologies are being evaluated to prevent further releases of tritium and uranium from the pits to groundwater. An amendment to the interim site-wide ROD is scheduled for 2006 in which a remedy for the Pits 3 and 5 areas will be selected.



Source: LLNL 2003l.

FIGURE 4.17.2.2–5.—*Distribution of Tritium in Groundwater in the First Water-Bearing Zone in Building 850/Pits 3 and 5 Operable Unit (Second Quarter, 2002)*

Building 854, Operable Unit 6

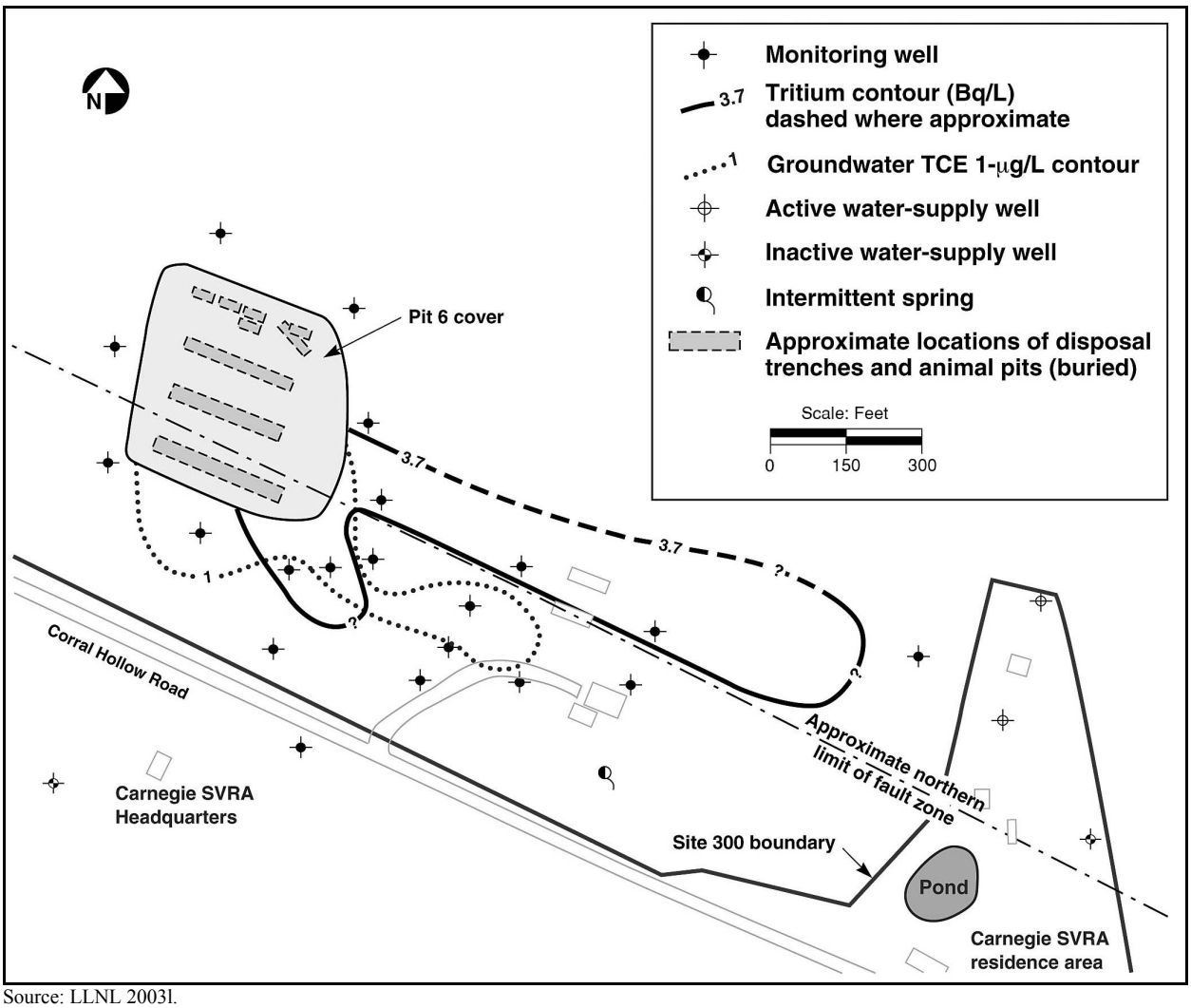
Facilities at the Building 854, 855, 856, and 857 complex were used between 1959 and 1970 to test the stability of weapons and weapon components under various environmental conditions and mechanical and thermal stresses. TCE was released to soil and groundwater through leaks and discharges of TCE-based heat exchange fluids from the brine system at Buildings 854D, E, and F. Discharge at the Building 854H drain outfall also resulted in releases of TCE to the ground surface. As a result, a plume of TCE extends approximately 3,000 feet from the Building 854 complex source area (Figure 4.17.2.2–6). The affected aquifer occurs at depths of 10 to 180 feet below ground surface. TCE concentrations in groundwater in the Building 854 area have decreased over time from an historical maximum of 2,900 micrograms per liter to 270 micrograms per liter in 2002. A septic system, located east of Building 855A, may have released nitrate to groundwater, although natural sources are likely to have contributed to nitrate mass as well. Perchlorate has also been detected in groundwater at concentrations exceeding the state action level.

The TCE brine system was removed in 1989. TCE-contaminated soil was excavated in 1983 in the vicinity of the Building 854H drain outfall and near Building 854F. Extraction and treatment systems were installed at and downgradient from the Building 854 source area in 1999 and 2000, respectively, to remove VOCs, nitrate, and perchlorate from the groundwater. The selected interim remedy for Building 854 includes groundwater and SVE and treatment. The volume of groundwater and soil vapor treated and mass of VOCs removed by the Building 854 treatment facilities through 2002 are presented in Table 4.17.2.2–1. The Building 854 treatment facility effluent discharges are regulated under Substantive Requirements for Wastewater Discharge issued by the Central Valley RWQCB.

Pit 6, Operable Unit 3

From 1964 to 1973, approximately 1,900 cubic yards of waste from the Livermore Site and Lawrence Berkeley National Laboratory were buried in 9 unlined trenches and animal pits at the Pit 6 landfill. As a result of rainwater percolating through the waste, VOCs (primarily TCE), tritium, nitrate, and perchlorate were released to the subsurface. These contaminants are present onsite in a shallow water-bearing zone approximately 80 feet below ground surface. VOC concentrations in groundwater have naturally attenuated by almost two orders of magnitude over the past few years and are near or below drinking water standards in all wells. Tritium activities exceed background in several wells, indicating a possible localized release. Maximum historical tritium activities in groundwater are well below the drinking water standard of 20,000 picocuries per liter. The extent of TCE in groundwater is shown in Figure 4.17.2.2–7. Perchlorate has been detected in several wells at concentrations above the state action level of 4 micrograms per liter.

In 1971, DOE/LLNL excavated portions of the waste contaminated with depleted uranium. In 1997, an engineered landfill cap was installed as a CERCLA removal action to prevent infiltrating precipitation from further leaching contaminants from the waste. Because of the decreasing TCE concentrations in groundwater, and the short half-life of tritium (12.3 years), the selected interim remedy for TCE and tritium at the Pit 6 landfill is monitored natural attenuation. During the period covered by the interim site-wide ROD, NNSA will continue evaluating the source, extent, and natural degradation of perchlorate and nitrate at the Pit 6 landfill. The interim remedy for these substances in groundwater is continued monitoring.



Source: LLNL 2003l.

FIGURE 4.17.2.2–7.—*Distribution of TCE in Groundwater in the Pit 6 Area (Fourth Quarter, 2002)*

Building 832 Canyon, Operable Unit 7

Contaminants, primarily VOCs, were released from Buildings 830 and 832 from the late 1950s to 1985 through piping leaks and surface spills. TCE was used as a heat exchange fluid as part of testing activities at these buildings. TCE concentrations in groundwater in the Building 830 area have decreased over time from an historical maximum of 30,000 micrograms per liter to 12,000 micrograms per liter maximum in 2002. As shown in Figure 4.17.2.2–8, TCE plumes extend approximately 4,600 feet downgradient from Buildings 830 and 832. Depth to groundwater ranges from 15 to 200 feet in this OU.

Nitrate and perchlorate are also present in groundwater at both Buildings 830 and 832. Nitrate contamination in groundwater may be the result of a combination of high explosive related testing and septic system releases, with a possible contribution from naturally occurring nitrate from local geologic units. High explosive compounds released may have degraded and migrated downward as nitrogenous compounds. Although the source of perchlorate is not known at this time, it may be that perchlorate was a component of high explosive test assemblies.

A groundwater and SVE and treatment system was installed at the Building 832 source area in 1999. Extraction and treatment systems were installed downgradient from the Building 830 source area and near the site boundary in 2000 to remove contaminant mass from groundwater and prevent the offsite migration of the plumes. The selected remedy for Buildings 830 and 832 includes continued soil vapor and groundwater extraction and treatment. The volume of groundwater and soil vapor treated and mass of VOCs removed by the Building 832 Canyon treatment facilities through 2002 are presented in Table 4.17.2.2–1. The Building 832 Canyon treatment facility effluent discharges are regulated under Substantive Requirements for Wastewater Discharge issued by the Central Valley RWQCB.

Site 300 Site-wide, Operable Unit 8

The Site 300 site-wide operable unit consists of several small release sites where active remediation is not required. These release sites include the Building 801D dry well and Pit 8 landfill, Building 833, the Building 845 firing table and Pit 9 landfill, and the Building 851 firing table.

Building 801D Dry Well and the Pit 8 Landfill

Waste fluid was discharged to a dry well located adjacent to Building 801D from the late 1950s to 1984, resulting in minor subsurface VOC contamination. VOC concentrations in groundwater are within drinking water standards. The dry well was decommissioned and filled with concrete in 1984. The adjacent Pit 8 landfill received debris from the Building 801 firing table until 1974, when it was covered with compacted soil. No contaminants have been detected in the vicinity of the landfill. The selected interim remedy for Building 801 and the Pit 8 landfill is enhanced vadose zone and groundwater monitoring of VOC concentrations to detect any future releases from the landfill.

Building 833

TCE was used as a heat-exchange fluid in the Building 833 area from 1959 to 1982 and was released through spills and rinse water disposal, resulting in minor VOC contamination of the shallow soil and perched, ephemeral groundwater. VOC concentrations have decreased over time, likely due to natural attenuation. The selected interim remedy for Building 833 is continued groundwater monitoring to ensure that TCE continues to attenuate.

Building 845 Firing Table and Pit 9 Landfill

High explosive experiments were conducted at the Building 845 firing table from 1958 to 1963. Leaching from firing table debris resulted in minor contamination of subsurface soil with depleted uranium and cyclotetramethylene tetranitramine. No groundwater contamination has been detected. Debris and gravel from the Building 845 firing table were routinely placed in the

adjacent Pit 9 landfill. No unacceptable risk to human health has been associated with the Pit 9 landfill and there is no evidence of any release from the landfill. The selected interim remedy for the Building 845 firing table and Pit 9 landfill is enhanced vadose zone and groundwater monitoring to detect any future releases from the landfill.

Building 851 Firing Table

The Building 851 firing table has been used for high explosive research since 1982. These experiments resulted in minor VOC, depleted uranium, metals, and the high explosive compound cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX) contamination in soils and groundwater. Contaminant concentrations in groundwater are below drinking water standards. No unacceptable risk to human health has been associated with contaminants in this area. In 1988, the firing table gravel was removed and has been replaced periodically since then. The selected interim remedy for Building 851 is continued groundwater monitoring to ensure that contaminant concentrations do not increase to a level presenting risk.

Continuing Characterization

Additional characterization is underway or planned at Building 865 (Advanced Test Accelerator), Building 812, and the former Sandia Test Site.

Building 865 (Advanced Test Accelerator)

The Building 865 area contains the Advanced Test Accelerator, a linear electron accelerator used for charged particle beam research, and control and support buildings. Freon-113 has been detected in groundwater monitor wells located downgradient from a former waste Freon-113 storage tank near the Building 865A machine shop. In 1988, the waste tank was removed and the use of Freon-113 was discontinued. Further characterization will be conducted at Building 865 to determine the nature and extent of contamination.

Building 812 Firing Table

The Building 812 firing table is used for explosives testing. Uranium-238 has been detected at activities up to 22,630 picocuries per liter in soil at a depth of 5 feet beneath the Building 812 firing table. Low activities of uranium-238 have been detected in groundwater collected from two cross-gradient wells near Building 812. Data are inadequate to confirm if contaminant releases have occurred in deeper soil/rock beneath the Building 812 firing table. Further characterization of the Building 812 firing table area is planned.

Sandia Test Site

SNL/CA operated a small, temporary firing table at Site 300 from about 1959 to 1960. The facility consisted of a portable steel building and six other smaller structures, surrounded by sandbags. The buildings and six structures, which are no longer present, may have been either high explosive test chambers or magazines used for storing high explosive materials. Shattered electronic components and structure remnants are still present on the ridge crest to the east and may represent the location of the firing table. Data are inadequate to confirm if contaminant releases have occurred at the Sandia Test Site. Further characterization of this area is planned.

4.17.2.3 *Remedial Actions*

Status of Remediation Efforts

Since 1992, dedicated groundwater and SVE and treatment facilities began operating at the eastern GSA, central GSA, and Building 834 areas. In 2002, eight portable treatment facilities also were operating. Thus, 11 treatment facilities that remove and treat VOCs operated throughout 2002. Twenty-one wells that extract only groundwater, 7 wells that extract only soil vapor, and 24 wells that extract both groundwater and soil vapor operated during 2002, treating 93.1 million liters of groundwater. The 24 wells that extract both vapor and groundwater and the 7 wells that extract only vapor removed 795,960 cubic meters of vapor. In 2002, the Site 300 groundwater and soil vapor treatment facilities removed 9.49 kilograms of VOCs. Since remediation efforts began in 1990, more than 865 million liters of groundwater and 3.93 million cubic meters of vapor have been treated, removing about 231 kilograms of VOCs. Table 4.17.2.2–1 summarizes CY2002 and cumulative totals of volumes and masses of contaminants removed from groundwater and soil vapor at Site 300.

The central GSA, eastern GSA, and two Building 830 treatment facilities discharge to surface drainage courses. Three treatment systems discharge to an infiltration trench. The other four treatment systems discharge to air by misting.

General Services Area

During 2002, the soil vapor extraction and treatment system in the central GSA dry-well source area was continuously operated and maintained to reduce VOC concentrations in soil vapors, remediate dense nonaqueous-phase liquids in the soil, and mitigate the VOC inhalation risk inside Building 875. The groundwater extraction and treatment systems in the central and eastern GSA areas were continuously operated and maintained to reduce VOC concentrations in the groundwater to MCLs, prevent further migration of the contaminant plume, and dewater the shallow water-bearing zone in the Building 875 dry-well area to enhance soil vapor extraction.

At the end of 2002, three wells were being considered for modification as extraction wells for the second phase of planned expansion to the groundwater extraction and treatment facility at central GSA. The addition of these extraction wells would enhance the system's ability to capture the contaminant plume and increase the mass removal. Treatability tests were being scheduled to determine if passive venting of soil vapor extraction wells in the central GSA area would result in a suitable long-term remedial technology.

Groundwater treated at the eastern GSA groundwater treatment facility was discharged offsite to Corral Hollow Creek, in accordance with the waste discharge requirements order. The central GSA groundwater treatment system is operating under substantive requirements for wastewater discharge issued by the Central Valley RWQCB. Both the central and eastern GSA treatment systems operated in compliance with regulatory requirements during 2002. LLNL submitted quarterly reports for the GSA treatment systems to the California EPA and the Central Valley RWQCB in accordance with the waste discharge requirements order for the eastern GSA and the substantive requirements for waste discharge for the central GSA.

Building 834 Complex

At the end of 2002, groundwater and SVE treatment, using air sparging and granular-activated carbon, respectively, were in progress. Work was initiated during 2002 to expand the well field to wells outside of the core area. Testing the use of aqueous phase granular activated carbon for VOC removal from the groundwater continued during 2002. Plans were being made for the replacement of the current air-sparging system with aqueous-phase granular-activated carbon.

In 2002, the groundwater and SVE treatment systems were operated at full scale for the first half of the year. Equipment problems, followed by programmatic activities, prevented any facility operations for the remainder of the year. The Defense Technologies Evaluations Program began conducting experiments in October 2002. These experiments continued into 2003 and will likely affect future operations. LLNL had been observing a significant drop in both groundwater and soil vapor VOC concentrations in the Building 834 area over the last couple of years. These declining VOC concentrations and temporary suspension of treatment operation provided an opportune time to allow for rebound of contaminants. LLNL plans to conduct detailed monitoring activities following completion of the Defense Technologies Evaluations Program experiments to evaluate potential contaminant rebound in both the vapor and aqueous phase. In situ biodegradation, via reductive dechlorination of TCE, occurs in areas within the Building 834 core area where sufficient amounts of silicon oils exist. However, it was demonstrated that this intrinsic microbial degradation is inhibited during periods of active soil vapor extraction because the soil vapor extraction system draws oxygen-rich vapors into the subsurface and the microbes become dormant. In essence, the SVE system acts like an on/off switch to control biodegradation. As such, allowing the system to remain off-line will promote biodegradation and will achieve some level of mass removal, although this mass is not easily quantified.

During 2001, the combined groundwater and soil vapor VOC mass removal at Building 834 was 31.96 kilograms. During 2002, the combined VOC mass removal at Building 834 was 6.0 kilograms. Table 4.17.2.2–1 shows the volumes of water and soil vapor treated and masses of VOCs removed at Building 834. Quarterly reports for the Building 834 treatment facility were submitted to the EPA, California EPA, and the Central Valley RWQCB in accordance with the substantive requirements for waste discharge. Because treated groundwater is discharged to misters and is not discharged to the ground, there are no treatment system surface discharge permit requirements for Building 834.

TABLE 4.17.2.3–1.—*General Services Area Groundwater Treatment System Surface Discharge Permit Requirements*

Parameter	Treatment Facility	
	Central General Services Area	Eastern General Services Area
VOCs	Halogenated and aromatic VOCs	Halogenated VOCs
Maximum daily	5.0 µg/L	5.0 µg/L
Monthly median	0.5 µg/L	0.5 µg/L
Dissolved oxygen	Discharges shall not cause the concentrations of dissolved oxygen in the surface water drainage course to fall below 5.0 mg/L	Discharges shall not cause the concentrations of dissolved oxygen in the surface water drainage course to fall below 5.0 mg/L
pH (pH units)	Between 6.5 and 8.5, no receiving water alteration greater than ±0.5 units	Between 6.5 and 8.5, no receiving water alteration greater than ±0.5 units
Temperature	No alteration of ambient receiving water conditions more than 3°C	No alteration of ambient receiving water conditions more than 3°C
Place of discharge	To groundwater during dry weather and to surface water drainage course in eastern GSA canyon during wet weather	Corral Hollow Creek
Flow rate	272,500 L/day (30-day average daily dry weather maximum discharge limit)	272,500 L/day
Mineralization	Mineralization must be controlled to no more than a reasonable increment	Mineralization must be controlled to no more than a reasonable increment
Methods and detection limits for VOCs	EPA Method 601—detection limit of 0.5 µg/L EPA Method 602—method detection limit of 0.3 µg/L	EPA Method 601—detection limit of 0.5 µg/L

Source: LLNL 2003l.
°C = degrees Celsius; EPA = U.S. Environmental Protection Agency; GSA = General Services Area; L = liter; µg/L = micrograms per liter; VOC = volatile organic compound.

High Explosives Process Area

In 2002, Phase 3 of the High Explosives Process Area remedial strategy was implemented with the installation of two more extraction wells near the center of mass of the TCE plume. With the addition of these wells, five groundwater extraction wells are in the high explosives process area and the total extraction flow rate is about 30 liters per minute.

To date, more than 10 million liters of groundwater have been extracted and treated by the three existing facilities in the high explosives process area. As presented in Table 4.17.2.2–1, 4.5 million liters of groundwater were extracted and treated during 2002. In addition to removal of 0.027 kilogram of VOCs, 0.134 kilogram of RDX, 0.034 kilogram of perchlorate have also been removed from extracted groundwater. Quarterly reports for the high explosives process area treatment facilities were submitted to the EPA, California EPA, and the Central Valley RWQCB in accordance with the substantive requirements for waste discharge.

Building 854 Area

During 2002, LLNL continued to define the extent of TCE in groundwater and the conceptual hydrogeological model. Three new monitoring wells were installed within the central portion of the groundwater TCE plume.

During 2002, 3.67 million liters of groundwater were treated and discharged at the two treatment systems (Table 4.17.2.2–1). A mass of 780 grams of VOCs, primarily TCE, was removed from this groundwater. The Building 854 Operable Unit discharges were in accordance with the draft Central Valley RWQCB substantive requirements for the Building 832 canyon and Building 854 OUs.

Building 832 Canyon

Table 4.17.2.2–1 shows the volume of water treated and the mass of VOCs removed in the treatment systems during 2002. The Building 854 OU discharges were in accordance with the draft Central Valley RWQCB substantive requirements for the Building 832 canyon and Building 854 Operable Units. Progress of the pump-and-treat systems and groundwater monitoring results are published quarterly.

Building 850/Pits 3 and 5 Operable Unit

At the end of 2002, a remedial investigation/feasibility study was in process for the Pits 3 and 5 area. The anticipated remedial technologies to be implemented at the landfill site include source isolation to prevent further release of tritium and uranium to groundwater. These technologies may include an upgradient groundwater interceptor trench and surface and shallow subsurface water diversion. LLNL is testing reactive media, such as cow bone char and fish bones (apatite mineral sources) and other novel sorbents, for possible deployment in a permeable reactive barrier for removal of depleted uranium from groundwater downgradient Pits of 5 and 7.

Although tritium continues to leach into groundwater from vadose zone sources at Building 850, the long-term trend in total groundwater tritium activity in this portion of the tritium plume is one of decreasing activity at approximately the radioactive decay rate of tritium. The extent of the 20,000 picocuries per liter-MCL contour for this portion of the plume is shrinking.

Nitrate and perchlorate in the Building 850/Pits 3 and 5 area occurred at maximum concentrations of 86 milligrams per liter and 44 micrograms per liter, respectively, in 2002. Trace amounts of TCE (less than 6.4 micrograms per liter) are also present in groundwater near Pit 5.

To determine the appropriate remediation strategy for the Pits 3 and 5 landfills, LLNL is completing a water budget for the Pits 3 and 5 valley, continuing to build and calibrate a three-dimensional geological structural model and model of groundwater flow and contaminant transport, and evaluating several remediation strategies to keep water from entering the landfills. These techniques include subsurface groundwater interceptor trenches, shallow terraced drains, horizontal dewatering wells, landfill grouting, other forms of permeability reduction, and in situ geochemical techniques using sorbents, such as bone apatite, to immobilize uranium in groundwater.

LLNL is also conducting field studies to determine how water recharges the perched water-bearing zone and enters the landfills. These studies include monitoring of wells completed at shallow depths, horizontal wells, and terraced drains, all completed in the hillslope west of the landfills where much of the recharge that enters the landfills originates. Additionally, LLNL is conducting laboratory treatability tests of cow bone char and fish bone in removing uranium from Pits 3 and 5 groundwater. Cow bone char mixed with inert sand has been emplaced in a portion of the alluvial aquifer containing uranium at Pit 5 to test the in situ removal of uranium from area groundwater. Wells within and downgradient of this emplacement are being monitored to define the long-term chemical effectiveness and hydraulic characteristics of the emplaced material. If successful, this emplacement may be expanded as a long-term remedy for depleted uranium in groundwater.

Proposed Remedial Actions

In 1992, a CERCLA federal facility agreement formalized the cleanup process for Site 300 remedial actions. LLNL and NNSA believe that the following proposed major milestones would best meet the criteria established in the agreement (EPA 1992a), the Interim Site-wide ROD for LLNL Site 300 (LLNL 2001u), and the most recent five-year reviews:

FY2004

- Prepare the Building 854 Draft Final Interim Remedial Design Report
- Prepare the Building 854 Final Interim Remedial Design Report
- Prepare the Building 850 Draft Interim Remedial Design Report
- Prepare the Draft Remedial Investigation/Feasibility Study for the Pit 7 Complex
- Conduct a public workshop for the Pit 7 Complex Draft Remedial Investigation/Feasibility Study
- Prepare the Building 850 Draft Final Interim Remedial Design Report
- Prepare the Building 850 Final Interim Remedial Design Report
- Prepare the Draft Final Remedial Investigation/Feasibility Study for the Pit 7 Complex
- Prepare the Final Remedial Investigation/Feasibility Study for the Pit 7 Complex
- Prepare the Building 812 Characterization Summary Report
- Install monitor wells for Building 865 (Advanced Test Accelerator)
- Construct the Building 832-PRX groundwater extraction and treatment facility in the Building 832 Canyon Operable Unit

FY2005

- Prepare the Draft Proposed Plan for the Pit 7 Complex
- Prepare the Building 832 Canyon Draft Interim Remedial Design Report
- Prepare the Draft Final Proposed Plan for the Pit 7 Complex
- Prepare the Final Proposed Plan for the Pit 7 Complex
- Conduct a public meeting for the proposed plan for the Pit 7 Complex
- Prepare the Site-wide Draft Remediation Evaluation Summary Report
- Conduct a public workshop for the Site-wide Draft Remediation Evaluation Summary Report
- Prepare the Draft Amendment to the Interim Site-wide ROD for the Pit 7 Complex
- Prepare the Building 832 Canyon Draft Final Interim Remedial Design Report
- Remove contaminated surface soil at Building 850
- Remove the contaminated sand pile at Building 850
- Prepare the Building 832 Canyon Final Interim Remedial Design Report
- Prepare the Building 865 (Advanced Test Accelerator) Characterization Summary Report
- Conduct surface soil sampling for the Sandia Test Site
- Construct the Building 829-SRC groundwater extraction and treatment facility in the High Explosives Process Area Operable Unit
- Construct the Building 817-PRX groundwater extraction and treatment facility in the High Explosives Process Area Operable Unit

FY2006

- Prepare the Site-wide Draft Final Remediation Evaluation Summary Report
- Prepare the Site-wide Final Remedial Evaluation Summary Report
- Prepare the Draft Final Amendment to the Interim Site-wide ROD for the Pit 7 Complex
- Prepare the Site-wide Draft Proposed Plan for the Final ROD
- Prepare the Final Amendment to the Interim Site-wide ROD for the Pit 7 Complex

- Conduct a public workshop for the Site-wide Draft Proposed Plan
- Prepare the GSA Draft Five-Year Review
- Prepare the Site-wide Draft Final Proposed Plan for the Final ROD
- Prepare the Site-wide Final Proposed Plan for the Final ROD
- Prepare the Pit 7 Complex Draft Interim Remedial Design Report
- Conduct a public meeting for the Site-wide Draft Proposed Plan
- Prepare the GSA Draft Final Five-Year Review
- Prepare the Building 834 Draft Five-Year Review
- Prepare the GSA Final Five-Year Review
- Hook up the Building 830-PRX extraction wells to the Building 830-SRC groundwater treatment system in the Building 832 Canyon Operable Unit
- Construct the Building 830-DIS groundwater extraction and treatment facility in the Building 832 Canyon Operable Unit
- Prepare the Sandia Test Site Characterization Summary Report

FY2007

- Prepare the Site-wide Draft ROD
- Prepare the Pit 7 Complex Draft Final Interim Remedial Design Report
- Prepare the Pit 7 Complex Final Interim Remedial Design Report
- Prepare the Building 834 Draft Final Five-Year Review
- Conduct a public workshop for the Site-wide ROD
- Prepare the Building 834 Final Five-Year Review
- Prepare the Site-wide Draft Final ROD
- Prepare the Site-wide Final ROD
- Prepare the Site-wide Draft Revised Remedial Design Work Plan
- Expand the Building 817-PRX groundwater extraction and treatment facility in the former high explosive lagoon area

- Construct the Building 832-DIS groundwater extraction and treatment facility in the Building 832 Canyon Operable Unit

FY2008

- Prepare the Site-wide Draft Final Revised Remedial Design Work Plan
- Prepare the Site-wide Final Revised Remedial Design Work Plan
- Prepare the Site-wide Draft Revised Compliance Monitoring Plan/Contingency Plan for Final Remedies
- Prepare the Site-wide Draft Final Revised Compliance Monitoring Plan/Contingency Plan
- Prepare the Site-wide Final Revised Compliance Monitoring Plan/Contingency Plan
- Install enhanced monitoring systems at the Pit 2, Pit 8, and Pit 9 landfills

Consistent with the agreement, the final selected remedies and cleanup standards will not be determined until the issuance of the Site 300 final ROD, scheduled for 2007. The interim ROD covers additional testing and evaluation of technologies, proposed final cleanup standards, and proposed investigations. NNSA expects GWTSs and other remedial actions to be in place and operational by 2009. NNSA will continue to operate treatment systems until cleanup levels are achieved and to manage remedial sites as part of the site-wide long-term stewardship effort.

4.17.3 Environmental Impacts of Contamination

In the 1992 LLNL EIS/EIR, environmental impacts resulting from a no-remediation scenario were presented. For this LLNL SW/SPEIS, a no-remediation scenario is also presented.

The extent of groundwater and soil contamination at the Livermore Site and Site 300 is discussed earlier in this section. Cleanup and remediation are required by law and LLNL is fully committed to these efforts; however, for purposes of a complete analysis of the existing setting, this section discusses the environmental effects on the existing environment assuming there is no remediation.

Over the last 10 years, LLNL, with Federal and state approval, has been actively remediating known areas of contamination. If no remediation of groundwater or soils were to occur, environmental impacts could result, as summarized below.

4.17.3.1 *Livermore Site*

In 1991, as part of the evaluation of remedial alternatives for groundwater and soil cleanup at the Livermore Site conducted under the Federal Facility Agreement (FFA), a no-remediation alternative was evaluated to provide a baseline from which to evaluate the various remedial alternatives. As remedial alternatives were implemented, as would be expected, remediation efforts have reduced the extent and concentration of contaminants in the environment.

Based on 2002 information, potential environmental impacts that could occur as a result of the no-remediation scenario are summarized as follows:

- Exceedance of regulatory agency-approved levels would place DOE in a situation of noncompliance with state and Federal laws.

- Contaminants in the unsaturated zone could migrate to groundwater in some areas of the Livermore Site.

- Concentrations of contaminants in groundwater would exceed state and Federal regulatory levels over broader areas.

- Degradation of the Livermore area groundwater would occur over a larger area as contamination plumes resume migration. The contaminant plumes would again migrate downgradient toward local water supply wells and city of Livermore municipal wells. This could inhibit future beneficial uses of increasingly greater proportions of the aquifer system. Over time, however, reduction in chemical concentrations would occur through natural attenuation processes, including biodegradation, dispersion, and abiotic degradation.

Twelve active domestic drinking water supply wells and seven industrial and/or agricultural supply wells are located within 1 mile of the Livermore Site VOC groundwater plumes (Hong 2002). These wells are generally either transverse, cross gradient or upgradient, or are in a different groundwater regime; therefore, they do not appear to be in the direct (downgradient) flow path of the plumes. Should lateral dispersal be significant or should a change in groundwater flow direction occur (which are both highly unlikely scenarios based on existing data), these wells could be affected by the advancing plumes. Additionally, although further development of the groundwater resource in the vicinity of the VOC plumes for domestic consumption is unlikely, development of additional water sources for irrigation is highly possible.

Groundwater data gathered in the remedial efforts indicate that impacts from VOCs in groundwater have stabilized and are declining (LLNL 2003l). If remediation were to cease and if contaminated groundwater were to reach municipal wells, economic impacts associated with the loss of water resources to local water consumers could result. Water purveyors supplying water pumped from municipal wells to constituents would need to treat the contaminated water sources or purchase water from other sources, resulting in increased water costs. Given the estimated maximum concentrations of TCE (6 parts per billion) and perchloroethene (5 parts per billion) would occur after 950 years (the MCLs of both these VOCs are 5 parts per billion), the impact would be minimal (Toblin 2003). This is a conservative estimate in that no degradation is assumed.

Assuming that no remediation occurs and contamination reaches municipal wells and that an individual consumes 2 liters of water each day from a municipal well in downtown Livermore for a 70-year (lifetime) period, the maximum additional cancer risk from a lifetime exposure to VOCs (TCE and perchloroethene are assumed to be the VOCs for the purpose of health estimates) could be 2×10^{-6} (Toblin 2003). This risk is much lower than the normal 1 in 4 cancer risk faced by all Americans due to both natural and artificial (i.e., medical) radiation exposures.

Assuming that an individual consumes 2 liters of water each day from a hypothetical drinking water well located 250 feet west of the Livermore Site boundary for a 70-year (lifetime) period, the maximum additional cancer risk from exposure to these same constituents would be 8×10^{-6}, based on present concentrations (~50 parts per billion of VOCs). However, administrative controls discouraging the use of this water for drinking and the continued availability of municipal water would greatly reduce, if not eliminate, this possibility.

Under the no-remediation scenario, tritium could migrate through soils to groundwater and be transported by groundwater. By the time the tritium reached the Livermore Site boundary, however, the tritium would have naturally decayed to lower concentrations.

Chromium in groundwater would again migrate downgradient and offsite. However, the levels of chromium are so low that combined with further dilution and natural attenuation, chromium would not likely represent an offsite health threat.

4.17.3.2 *Site 300*

Environmental investigations and cleanup activities at Site 300 began in 1981. Site 300 became a CERCLA site in 1990, when it was placed on the NPL. At present, eight CERCLA environmental restoration Operable Units are being managed to mitigate contamination at Site 300. These Operable Units are the GSA; Building 834 Complex; High Explosives Process Area; Building 850/Pits 3 and 5; Building 854, Pit 6; Building 832 Canyon, and other areas at Site 300. Details of the extent of contamination and proposed remedial action strategies are presented in Section 4.17.3, Site Contamination—Site 300.

Based on 2002 information, environmental impacts that could occur as a result of the no-remediation scenario are summarized as follows:

- Exceedance of regulatory agency-approved levels would place DOE in a situation of noncompliance with state and Federal laws.
- Contaminants in unsaturated zone soil could migrate to groundwater in many of the Operable Units.
- Concentrations of contaminants in groundwater and soil could again exceed state and Federal regulatory levels.
- Degradation of Site 300 groundwater over a larger area could occur as the plumes resume migration. The VOC and other contaminant plumes would migrate downgradient toward the site boundaries.

Groundwater data gathered in the remedial efforts indicate that impacts have stabilized and are declining (LLNL 2003l). If the no-remediation scenario were to occur, this trend would reverse.